Tropical Atlantic bias dependence on horizontal resolution in ECHAM5

Jan Harlaß, Mojib Latif, Vladimir Semenov
Helmholtz Centre for Ocean Research Kiel GEOMAR, contact: jharlass@geomar.de

Abstract

The **Tropical Atlantic (TA)** region still exhibits large errors in simulating the mean climate with general circulation models. One aspect of eliminating these biases is to increase the horizontal model resolution, which we did in a series of global atmosphere only ECHAM5.4 simulations. The same present day forcing, amongst others observed daily SST from NOAA, is used to simulate the climate from **1982 to 2009** with 6 different horizontal resolutions: T031 (~3.75°), T042 (~2.8°), T063 (~1.87°), T106 (~1.12°), T159 (~0.75°), T213 (~0.56°). As a statistical measure of the average model-performance error, the **Mean Absolute Error (MAE)** is calculated, which is an ambigious meassure of the average error magnitude.

Conclusions

✔ An increasing horizontal grid resolution does reduce the magnitude of common biases in the Tropical Atlantic, but their spatial patterns remain.

✔ Relatively small changes for resolutions higher than T106.

Tropical 10m wind bias

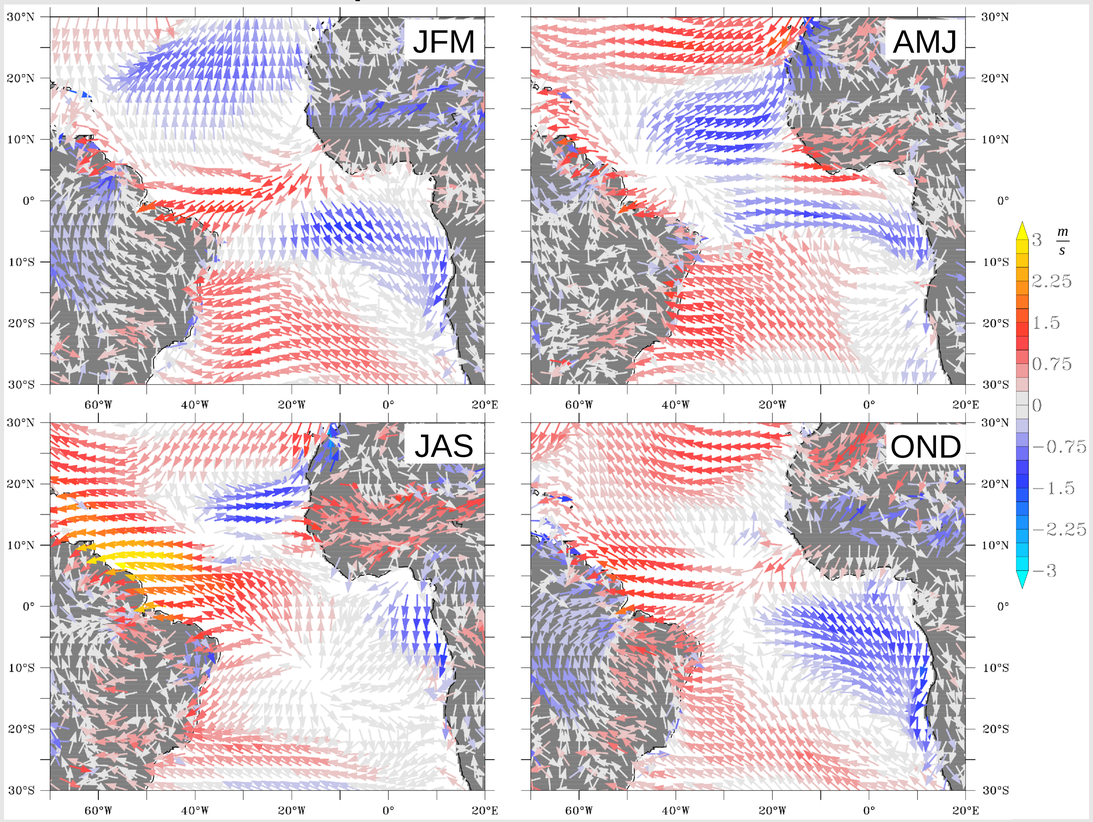

Fig. 1. Seasonal averaged 10m wind speed biases (m/s) from 1982 to 2009 relative to ERA-Interim, for grid resolution T213. Colors denote differences in 10m wind speed, arrows in 10m wind direction.

Bias dependence on resolution

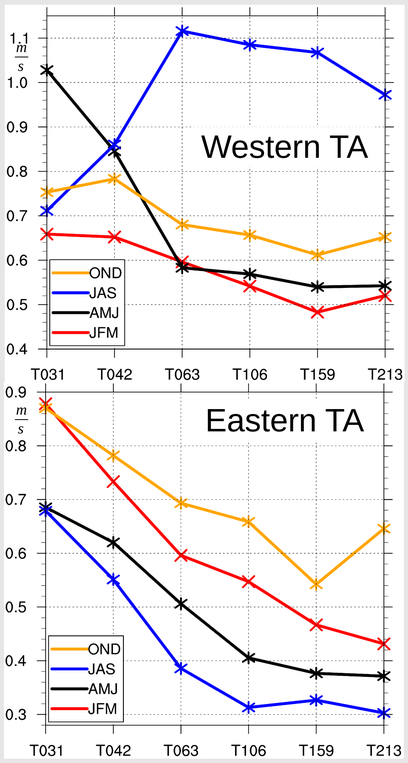

Fig. 2. Mean absolute error (MAE) of 10m wind speed bias (m/s) versus horizontal grid resolution. Colors denote sesaons. Upper: WTA, 10°S–10°N, 60°W–10°E, lower: ETA, 20°S–5°N, 10°W–15°E.

10m winds

The 10m wind speed biases (compared to ERA-Interim reanalysis) are similar in all 6 horizontal resolutions. Main biases (Fig. 1) are too weak southerly (strong easterly) winds in the Eastern (Western) TA, especially during JAS.

The MAE does improve over all seasons in the Eastern TA (ETA, 20°S–5°N, 10°W–15°E), where it is smallest in JAS and largest in OND, Fig. 2. Reduction of MAE is almost equally distributed between the U- and V-components, except for AMJ, where the V-component reduces less (-20% instead of -60%). Biases in the Western TA (WTA, 10°S–10°N, 60°W–10°E) improve less during autumn and winter, reduce stronger in spring, but roughly double in JAS. The latter can be attributed to an increase in the MAE of the U-wind by +40%, whereas MAE of V-wind reduces by -20%.

Tropical precipitation bias

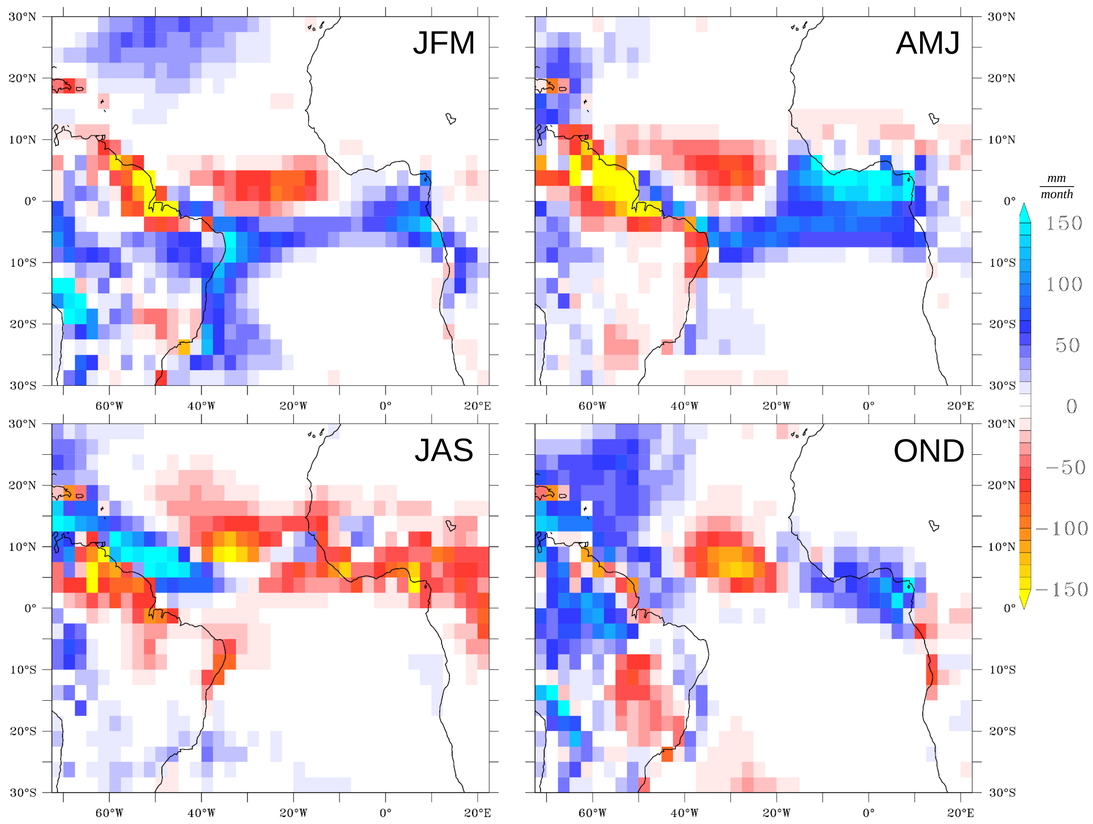

Fig. 3. Seasonal averaged total precipitation biases (mm/month) from 1982 to 2009 relative to GPCP, for grid resolution T213.

Bias dependence on resolution

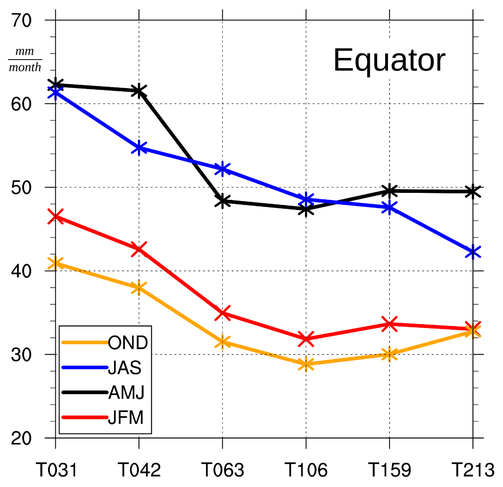

Fig. 4. Mean absolute error (MAE) of total precipitation bias (mm/month) versus horizontal grid resolution over 10°S-15°N and 70°W-20°E. Colors denote sesaons.

Precipitation

Total precipitation (Fig. 3), compared to the Global Precipitation Project (GPCP), shows a southward shift of the main precipitation band in JFM and AMJ. Further, there is too less (much) rain in the eastern (western) TA during boreal summer. OND displays a wetter ETA and WTA, but drier central TA.

Representation of total precipitation benefits from a higher horizontal resolution (Fig. 4).

MAE along the equator (10°S-15°N, 70°W-20°E) reduces equally across the seasons by about -20% and is strongest during boreal spring and summer.

Tropical cloud cover bias

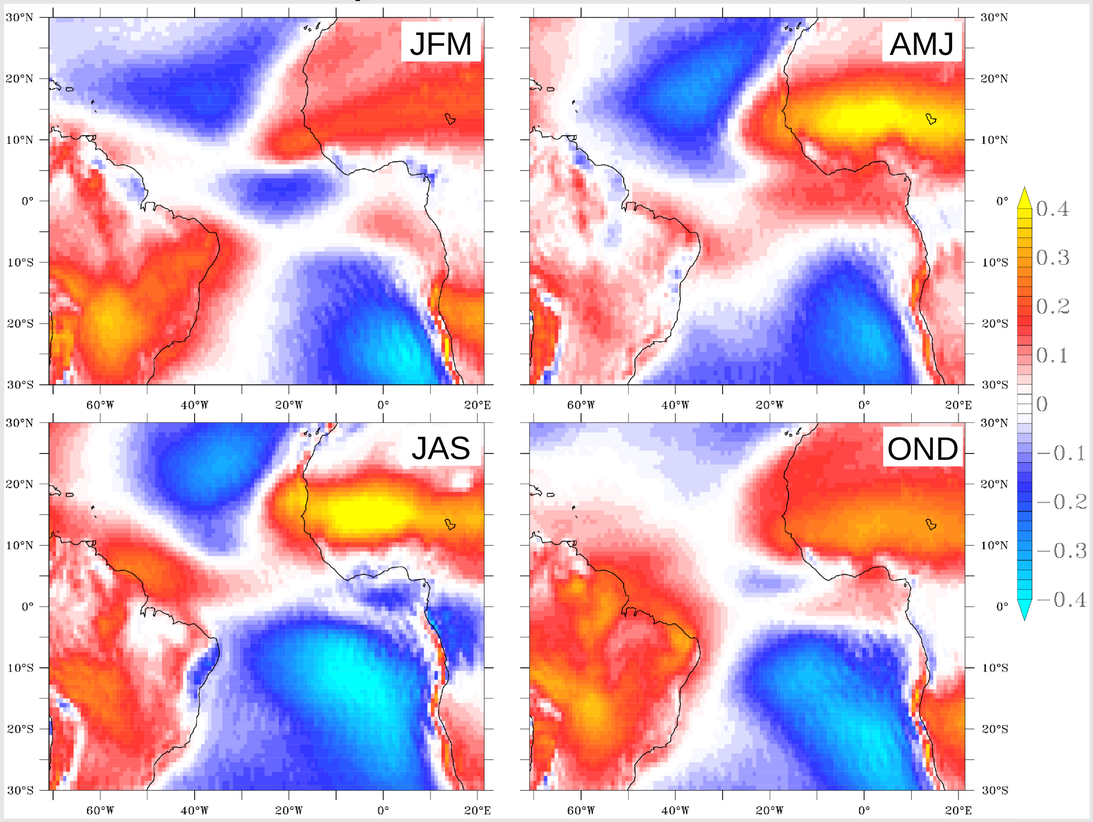

Fig. 5. Seasonal averaged total cloud cover biases (fraction) from 1982 to 2009 relative to ERA-Interim, for grid resolution T159.

Bias dependence on resolution

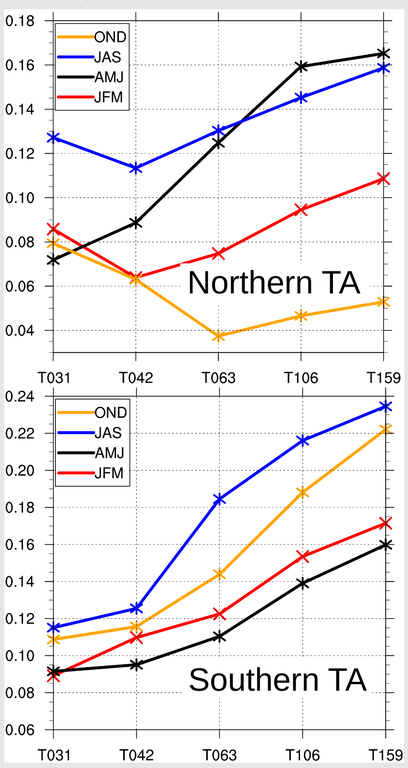

Fig. 6. Mean absolute error (MAE) of total cloud cover bias (fraction) versus horizontal grid resolution. Colors denote sesaons. Upper: NTA, 10°N–30°N, 50°W–20°W, lower: STA, 40°S–10°S, 20°W–10°E.

Cloud cover

Total cloud cover (Fig. 5), compared to ERA-Interim reanalysis, reveals too much cloud over Northern Africa, where subsequently less incoming solar radiation leads to colder 2m temperatures (-3°C). Cloud cover over Northern Brazil is simulated quite well during JFM and AMJ, but there are too much clouds (and rain) during JAS and OND.

Too less marine stratocumuls are simulated in the Northern and Southern TA, especially during JAS and OND, which consequently leads to a warming near the surface. The MAE (Fig. 6) roughly doubles during all seasons in the Southern TA and during JAS in the Northern TA.

Note: Due to a prolonged shutdown of a computing centre used by the authors, cloud cover data for T213 were not available.